JOURNAL OF
EMERGING INVESTIGATORS

Article

# Efficacy of electrolytic treatment on degrading microplastics in tap water

**Olivia Schroder[1], Joseph Rasmus[1]**
[1] Williamston High School Math and Science Academy, Williamston, Michigan

## SUMMARY

**Microplastics, or plastic fibers less than five millimeters in length, are a significant environmental problem and are extremely difficult to remove from water. In this experiment, we quantified the effect of electrolysis on the degradation of microplastics in tap water and explored electrolysis as a potential solution to this issue. We hypothesized that an electrolytic treatment would disassemble microplastic molecules, as it does with water. Treated water consisted of samples electrolyzed for 30 minutes in an electrolysis machine, while samples of untreated tap water were the control. We examined filters under a microscope before and after filtration of the water samples to determine the number of net microplastics in every sample. Overall, control samples demonstrated a greater number of net microplastics than experimental samples (Mann-Whitney U, $p$ = 0.047). Thus, we conclude that electrolysis is a valid and practical method to degrade microplastics in tap water because of its high efficiency within a short duration of time. These findings could be of great value as they have the potential to improve the quality of drinking water, and by extension, public health. This research indicates electrolysis could be advantageous over many other methods of water purification in respect to microplastics.**

## INTRODUCTION

The ubiquitous use of plastic in modern society has caused extensive displacement of the material into natural environments globally. When exposed to harsh conditions, plastic breaks down into smaller pieces (1). Some of these are characterized as microplastics, which are fibers less than five millimeters in length. Microplastics contaminate nearly all of the world's water supply and are considered a rising threat to water sources (2). The danger lies in their durable and small nature, and the fact that they can absorb toxins and then be ingested (3). They cannot be easily degraded into molecules that do not pose these threats (4). Microplastics are toxic to humans and have numerous negative health effects, such as increased stress, inflammation, and brain damage (5). Extremely small pore filters are required to filter microplastics out of water, which makes the filtration process very slow (5). Therefore, a different method of purifying water would be advantageous.

Electrolysis is a process that directs an electric current through a substance to chemically change it by adding or removing electrons in an electrolytic cell (6). The electrolysis of water is represented by the equation $2H_2O \rightarrow 2H_2 + O_2$, so it separates the substance into different parts (6). This same separation effect could possibly be induced in microplastics within water, serving as a possible solution to the issue of inefficient filtration methods and the proliferation of microplastics in drinking water. Concepts similar to this have already been explored in several other published procedures, such as an experiment testing degradation of polyvinyl chloride (PVC) microplastics with a graphite and titanium oxide cathode, with promising results suggesting a high rate of removal of microplastics from water samples (7). In order for this to become a widely accepted and utilized method, more research is necessary to validate its efficacy and practicality.

This experiment addressed the need to test the feasibility of electrolytic methods on degrading microplastics in water. Depolluting drinking water would be beneficial to human health and is increasingly important due to the rising presence of microplastics in water. This research also looked to offer an alternative to difficult methods of removing and degrading microplastics, such as filtration and microbial degradation. We hypothesized that an electrolytic treatment would degrade microplastics in tap water. We compared net microplastics in control and treated samples and found the difference to be statistically significant using the Mann-Whitney U test ($p$ = 0.047). Therefore, this electrolytic method was concluded to be effective in degrading microplastics.

## RESULTS

We divided samples of tap water into two groups: control and experimental. The control group was unaltered, and we treated the experimental group with an electrolysis machine for 30 minutes. We identified microplastics visually using a microscope after filtering them from the water samples **(Figure 1)**.

Pre-counts of filter papers had a mean of 1.6±1.2 microplastics for control filters and 2.2±1.9 for the experimental filters **(Figure 2)**. We subtracted the number of microplastics found during a pre-count from the post-count to produce the net count. The mean net count of microplastic for the experimental group was 0.423 per filter (n=26), and the mean of the control group was 1.231 per filter (n=26). The net counts of the control group also varied much more widely than the experimental, as its standard deviation was over two times as large **(Figure 3)**. The control had several trials with a net of zero microplastics, but the maximum was five, while no experimental trials had net counts greater than three. The distributions of both the experimental and control net microplastic counts were heavily right skewed and therefore not normal distributions. We converted the net results to concentration of microplastics per milliliter by dividing by the

JOURNAL OF
EMERGING INVESTIGATORS

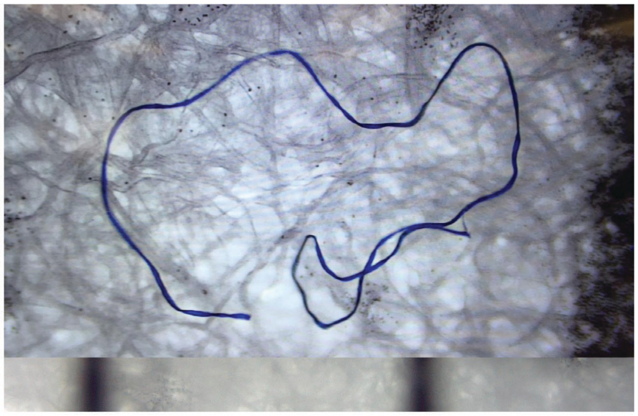

**Figure 1: Example of microplastic under the microscope.** The microplastic is easily identified by a blue or red color and plastic-like texture. Lines on the grid shown along the bottom are 0.1 cm apart.

volume of the samples (14 mL), which yields a mean difference of 0.058 microplastics per milliliter **(Figure 3)**. There was a statistically significant difference in the concentration of microplastics in water treated by electrolysis compared to untreated controls (Mann-Whitney U, $p$ = 0.047). Thus, the results supported the hypothesis of an electrolytic treatment decreasing concentration of microplastics.

## DISCUSSION

The results of the experiment confirmed that electrolysis degrades microplastics in tap water as we found significantly fewer microplastics in samples of electrolyzed water than control samples. The advantages of electrochemical methods of separating or degrading microplastics over filtration or sedimentation are that they do not require organisms or substances, and they are generally energy efficient (5).

A primary limitation of the experiment was that it only tested one duration of electrolysis (30 minutes). Therefore, this experiment was not able to determine the optimal duration of electrolysis for maximized efficiency. A more thorough, successive research project would monitor the effects of different lengths of electrolytic treatment. Another improvement that could be made would be to leave the control samples in the electrolysis machine while not running in order to control more variables, such as the materials of containers for the samples. This research also did not test different voltages of electrolysis, as a more intense treatment has already been demonstrated to be more effective than a lower voltage (8). Additionally, this experiment did not test different settings of cathodes, which could affect results. More advanced techniques such as light scattering could have detected more information about the microplastics.

This research could be improved by performing more trials and using a larger volume of water for every sample. Filter paper with a smaller pore size could detect more plastics, but it would take a larger amount of time to perform trials. If there was a larger sample size, measurements of concentrations of microplastics could be more accurate, and there would be a smaller margin of error in the statistical analysis. It is possible that mistaking microplastics for other particles during counts, or vice versa, could have been a source of error as well. In future experiments, it would be beneficial to use different types of synthetic microplastics to test how different materials are affected and how they differ from each other in degradation efficacy.

Compared to other studies, the methodology in our experiment was much simpler in terms of variables examined and materials used. However, our experimental design may have more similarities with a real-world application than another researcher's design using synthetic wastewater with added microplastics (8). Although artificial samples

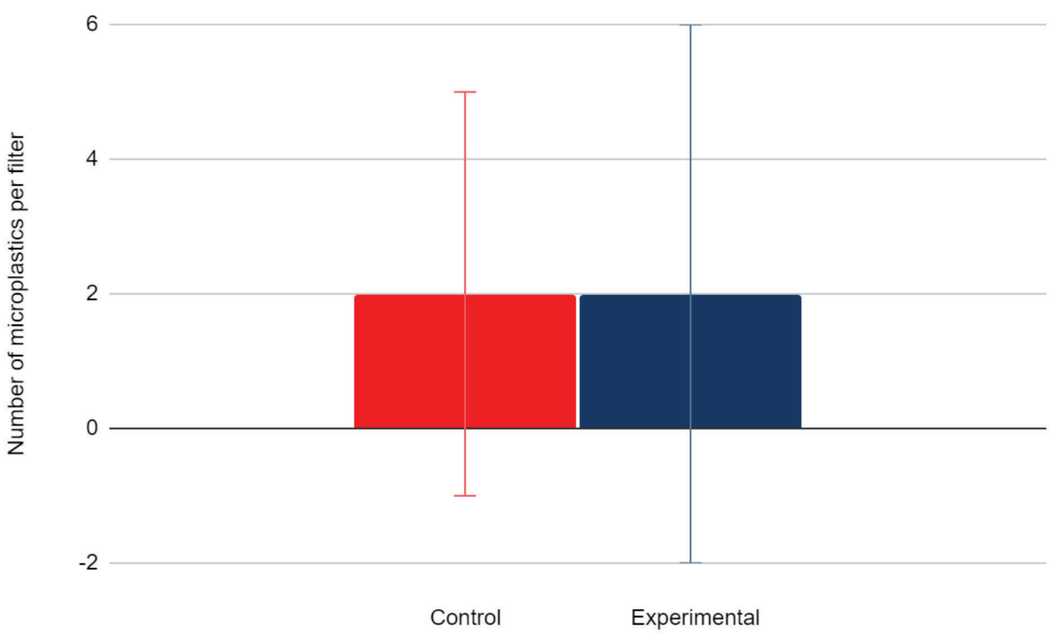


**Figure 2: Number of microplastics found during pre-count.** Number of microplastics found on filters before filtration for control and experimental (electrolytic treatment) groups. (n=26). The data is represented by the median +/- interquartile range.

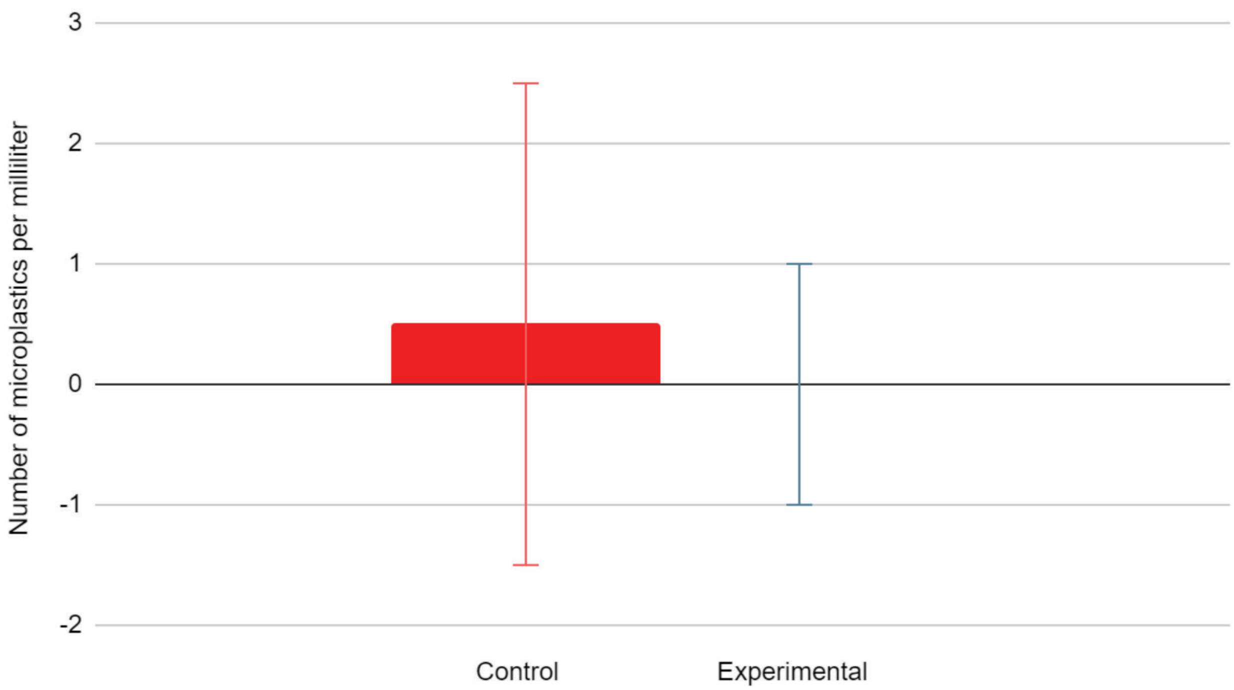


**Figure 3: The electrolysis treatment group contained fewer microplastics.** The concentration of microplastics in water samples was measured with a filter and microscope (n=26). The data is represented by the median +/- interquartile range. Mann-Whitney U $p = 0.047$.

may yield more accurate and easily measured results when experimenting, they are not as similar to real tap water, so research on both types of samples is required. This research is complicated by the fact that there is no detectable correlation between chemical makeup of electrodes and microplastics concerning efficacy. Our method may have potential to function on a large scale because it could be more efficient than other leading methods of microplastic removal. The conclusions of our experiment could be implemented in homes or drinking water treatment facilities because of the short duration of electrolysis necessary to yield significant results. The decrease in microplastics in tap water resulting from this treatment could markedly improve environmental health. Due to the nebulous nature of microplastics, it is difficult to deduce how significant the impact of this procedure on human health would be.

## MATERIALS AND METHODS

This research compared an experimental electrolytic treatment group with a control group of untreated tap water collected from our laboratory sink in Ingham County, Michigan, with 26 samples in each group. Filters (No.1 Whatman 55-millimeter filter, 11 µm pore size) were used only to quantify microplastics in the sample and were not a removal method being tested. A ratio of half of a teaspoon of sodium chloride to 500 mL of water was prepared to allow the water in the samples to conduct electricity and be electrolyzed in the machine (E-C Apparatus Corporation EC-400). For both groups, the first step was to examine the filter between two glass slides under the microscope (Meiji Techno model MC500W-G1) using 4x magnification **(Figure 1)**. We scanned filter paper for microplastics before use to avoid counting pre-existing microplastics as part of the sample. We counted microplastics by eye, identifying them by their smooth, plastic-like texture and usual blue or red color. They were typically 0.01 to 0.15 cm long and relatively easy to identify because of their bright colors. The number of microplastics found was recorded. We printed a grid onto the filters to make examination more efficient and facile. During the control trials, we filtered 14 mL of water from the supply through this filter, using a Buchner funnel, a rubber hose, and a faucet aspirator.

The first action for the experimental trials was to pour approximately 30 mL of water from the supply into the electrolysis machine and operate it for 30 minutes at 75 volts using constant voltage. Firstly, the water electrolyzed by the anode was emptied, and then the water over the cathode, which produced 14 mL of water total (30 mL was poured in and 14 mL was recovered). The sampling from each electrode alternated in order to control for possible differences in degradation between them, as cathodes have been found to have a greater effect on microplastics (8). We filtered these samples using the same filtering procedure as the control. We dried the filter in an incubator at 37 °C in a glass Petri dish for 24 hours. The dry filter was then examined under the microscope, while recording the number of microplastics.

We kept all filters and samples during the experiment in a glass beaker or Petri dish covered with a glass lid. During filtration, the Buchner funnel was also covered by a glass lid. Use of a stirring rod before taking water from the supply ensured that the microplastics and salt were distributed evenly in the samples.

**Received:** June 7, 2022
**Accepted:** September 26, 2022
**Published:** April 23, 2023

## REFERENCES

1. Avio, Carlo Giacomo, *et al.* "Plastics and Microplastics in the Oceans: From Emerging Pollutants to Emerged Threat." *Marine Environmental Research,* vol. 128, July 2017, pp. 2–11. doi:10.1016/j.marenvres.2016.05.012.
2. Rogers, K. "Microplastics." *Encyclopedia Britannica,* 5 Apr. 2022, www.britannica.com/technology/microplastic. Accessed 6 Nov. 2022.
3. Rahman, Arifur, *et al.* "Potential Human Health Risks Due to Environmental Exposure to Nano- and Microplastics and Knowledge Gaps: A Scoping Review." *Science of The Total Environment,* vol. 757, 3 Dec. 2020, pp. 143872. doi:10.1016/j.scitotenv.2020.143872.
4. "Microplastics". *National Geographic Society,* 20 May 2022, pp. 1-3, www.education.nationalgeographic.org/resource/microplastics. Accessed 24 Aug. 2022.
5. Sharma, Surbhi, *et al.* "Microplastics in the Environment: Occurrence, Perils, and Eradication." *Chemical Engineering Journal,* vol. 408, 15 Mar. 2021, p. 127317. doi:10.1016/j.cej.2020.127317.
6. "Electrolysis." *Encyclopedia Britannica,* 6 Feb. 2022, www.britannica.com/science/electrolysis. Accessed 10 Aug. 2022.
7. Miao, Fei, *et al.* "Degradation of Polyvinyl Chloride Microplastics via an Electro-Fenton-like System with a tio2/Graphite Cathode." *Journal of Hazardous Materials,* vol. 399, 15 Nov. 2020, p. 123023. doi:10.1016/j.jhazmat.2020.123023.
8. Elkhatib, Dounia, *et al.* "Electrocoagulation Applied for the Removal of Microplastics from Wastewater Treatment Facilities." *Separation and Purification Technology,* vol. 276, 1 Dec. 2021, p. 118877. doi:10.1016/j.seppur.2021.118877.